7.8 Flood Control

The CALFED Bay-Delta Program would substantially improve flood protection in the Delta Region. The benefits of an improved Delta levee system include greater protection to Delta agricultural resources, municipalities, infrastructure, wildlife habitat, and water quality as well as navigation and conveyance facilities.

7.8 Flood Control

7.8.1 SUMMARY

The benefits of an improved Delta levee system include greater protection to Delta agricultural resources, municipalities, infrastructure, wildlife habitat, and water quality as well as navigation and conveyance facilities. The wide range of beneficiaries of improved flood protection in the Delta Region includes Delta local agencies; landowners; farmers; boaters; wildlife; and operators of railroads, state highways, utilities, and water distribution facilities. Delta water users and exporters also benefit from increased protection of water quality. Federal interests benefit from improvements to conveyance, navigation, commerce, and the environment and from reduced flood damage.

The wide range of beneficiaries of improved flood protection in the Delta Region includes Delta local agencies; landowners; farmers; boaters; wildlife; and operators of railroads, state highways, utilities, and water distribution facilities.

One objective of the CALFED Bay-Delta Program (Program) is to manage the risk of losing existing land uses due to deterioration of existing Delta conveyance and flood control facilities, since loss of these facilities could result in the catastrophic inundation of Delta islands.

Preferred Program Alternative. Flood stages generally would be similar to existing levels. Localized south Delta stage increases could result during the non-flood season due to minor flow impediments but would not significantly affect the flood control system. Seepage through levees would continue as an ongoing process, especially in the Delta Region.

Increases in shallow flooding for habitat would increase the potential for seepage. Inspection, maintenance, and repair of the flood control system would be easier because setback levees would be designed to facilitate these tasks. However, emergency response capabilities would not be significantly changed until the Levee System Integrity Program is fully implemented.

Minor increases in sedimentation could result from generally reduced velocities in shallow flooded areas established for habitat. Increased settlement is expected for levees that could be set back as far as 500 feet from the current levee locations, requiring long construction periods and increased initial maintenance. Channel capacities would be similar to existing conditions, with minor decreases in capacity possible where sedimentation accompanies slow velocities.

Watershed Program actions that restore water retention features of watersheds, such as revegetation and runoff control, could benefit flood control resources.

Levee scour would be reduced at locations where channel widening is planned. Channel widening would improve flood flow conveyance capacities.

Subsidence would continue to occur on the interior of the islands where peat soils degrade, but levee design will address subsidence adjacent to the levee in critical areas. Wind-generated wave erosion would increase near setback levees and on flooded islands, as greater expanses of water would be subject to wind-fetch.

Under all alternatives, annual loss is estimated to decline by as much as 65%, to about $140 million on an expected annual basis. Costs associated with flood control also are estimated to be substantial. Depending on how these costs are allocated to beneficiaries, they could induce changes in land use, water use, property values, and regional economic activity.

Under all alternatives, annual loss is estimated to decline by as much as 65%, to about $140 million on an expected annual basis. Costs associated with flood control also are estimated to be substantial.

Additional changes in costs and benefits could occur in the Sacramento River and San Joaquin River Regions due to reoperation of reservoirs for Ecosystem Restoration Program flows and diversion of water to off-stream storage. Existence of surface water storage sites could provide flood control benefits to downstream residents, and could allow some reoperation of existing reservoirs for potential flood control benefit. No Program actions are expected to influence flood control costs or benefits in the Bay Region or in the Other SWP and CVP Areas.

Alternatives 1, 2, and 3. Except for decreased flood stages in the north Delta under Alternatives 2 and 3, conditions under Alternatives 1, 2, and 3 related to flood control would be similar to those described for the Preferred Program Alternative.

The following table presents the potentially significant adverse impacts and mitigation strategies associated with the Preferred Program Alternative. Mitigation strategies that correlate to each listed impact are noted in parentheses after the impact.

Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative

Potentially Significant Adverse Impacts

Impacts on levee stability from levee and berm vegetation management practices for habitat purposes (1,2).

Reduced levee stability from habitat restoration using conservation easements along riparian corridors (1,2,4).

Increased seepage on adjacent islands, possibly leading to flooding from seepage-induced failure from shallow flooding of Delta islands susceptible to subsidence (5,6,7,8).

Increases in wind-fetch and wave erosion on landside levee slopes from island flooding (9,10,11).

Potentially Significant Adverse Impacts and Mitigation Strategies Associated with the Preferred Program Alternative (continued)

Increased levels of flooding downstream of diversions after removal of diversion structures and other obstructions to flow in the Sacramento River tributaries (3).

Increased flood stages along streams due to increases in the roughness of the stream channel from vegetation stream banks (4).

Potential localized subsidence, resulting in levee slumping cracking if occurring near levees, caused by potential increases in groundwater pumping (14, 18).

Increased stage upstream of and possibly decreased stage downstream from gate structures located in channels that reduce the channel's flood flow conveyance (19).

Adverse effects on water quality from the use of dredged materials (12,13,14,15,16).

Mitigation Strategies

1. Allowing reasonable clearing of deep-rooted trees and shrubs from levee side slopes to support inspection, maintenance, repair, and emergency response, while preserving some habitat values.

2. Permitting clearing of deep-rooted shrubs and trees on levee side slopes. Trees and shrubs should be allowed to grow only on adjacent berms. If roots penetrate levees, fill materials should be added to levee landside slopes in order to construct a partial setback levee and increase stability.

3. Widening streams downstream of removed water diversion structures to increase conveyance capacity.

4. Incorporating flood control criteria into the design of stream bank revegetation projects. For example, by increasing the width of vegetated sections to maintain conveyance capacity, the net effect of vegetation on flood control would be negligible.

5. Identifying locations susceptible to seepage-induced failure on Delta islands that may be intentionally flooded for habitat.

6. Implementing a seepage monitoring program on nonflooded islands adjacent to potential shallow-flooded islands.

7. Developing seepage control performance standards to be used during island flooding and storage periods to determine net seepage caused by shallow flooding.

8. Improving levees to withstand expected hydraulic stresses and seepage.

9. Designing erosion protection measures to minimize or eliminate wave splash and run-up erosion.

10. Using riprap or another suitable means of slope protection to dissipate wave force.

11. Constructing large wind/wave breaks in the flooded islands to reduce wind-fetch and erosion potential.

12. Identifying and investigating issues regarding the beneficial reuse of dredge material.

13. Continuing the studies concerning reuse of beneficial Bay dredge material in the Delta for potential water quality impacts related to salinity, metals mobilization, and other environmental and health hazards.

14. Investigating the cost effectiveness and safety of using sediment traps as a source of borrow.

15. Investigating all potential sources of borrow and the cost effectiveness of each source's use for levee rehabilitation and construction.

Potentially Significant Adverse Impacts and Mitigation Strategies
Associated with the Preferred Program Alternative
(continued)

16. Preparing a borrow plan that includes future costs and options for obtaining adequate quantities of borrow needed for implementation of the Levee System Integrity Program.

17. Identifying existing or planned wells that could affect groundwater and substrate conditions underlying nearby levees or flood control facilities.

18. Providing incentives to terminate use of wells that can adversely affect levee stability, reducing their pumping volume to safe withdrawal levels as they affect substrate stability, or otherwise replacing them with sources that could not affect levee stability.

19. Designing structures to minimize the loss of channel conveyance at gate structures located in channels.

No potentially significant unavoidable impacts on flood control are associated with the Preferred Program Alternative.

7.8.2 AREAS OF CONTROVERSY

Under CEQA, areas of controversy involve factors that are currently unknown or reflect differing opinions among technical experts. Unknown information includes data that are not available and cannot readily be obtained. The opinions of technical experts can differ, depending on which assumptions or methodology they use. Below is a brief description of the areas of controversy for this resource category. Given the programmatic nature of this document, many of these areas of controversy cannot be addressed; however, subsequent project-specific environmental analysis will evaluate these topics in more detail.

Seismic risk has been quantified only for the existing Delta levee system.

Seismic risk has been quantified only for the existing Delta levee system. Studies have not been conducted to determine the comparable seismic risk for each alternative, nor has the seismic risk been compared to state-wide seismic risk and the overall flood risk. Although the necessary information is available, these calculations would involve extensive studies.

The rate of sea-level rise in the Delta is unknown.

Sea-level rise can be important to flood control plans, as it raises predicted water surface profiles over time. The rate of sea-level rise in the Delta is unknown. Levees can be built higher to account for sea-level rise projected over the project life, at whatever rate is determined.

Dredging has long been controversial in the Delta because permits are both issued on a case-by-case basis for such a common and necessary activity.

Dredging has long been controversial in the Delta because permits are both issued on a case-by-case basis for such a common and necessary activity. The development of a General Permit (a permit allowing all Program-related dredging) is hindered by the lack of available data regarding impacts associated with dredging. The Program plans to develop this information.

In addition, the lack of suitable fill material in the Delta has suggested the use of dredged materials from outside the Delta system, especially from San Francisco Bay. But material from outside the Delta may not be suitable for Delta disposal. Although the Program supports the efforts of others to resolve this controversy, it does not plan to study the issue at this time.

The Program position on flood control is expressed in the Program mission statement and objective, which are described in Chapter 1.

7.8.3 AFFECTED ENVIRONMENT/ EXISTING CONDITIONS

The flood control systems described here are governed by federal, state, and local agencies. Levee systems are referred to as federal project levees or local non-project levees. The San Joaquin River Flood Control Project and the Sacramento River Flood Control Project (SRFCP), built by the Corps and turned over to the state for maintenance, provide flood control for the lower reaches of these rivers and into the Delta.

The flood control systems described here are governed by federal, state, and local agencies. Levee systems are referred to as federal project levees or local non-project levees.

Project levees are associated primarily with conveying flood flows and maintaining the Sacramento Deep Water Ship Channel. The project levees work in conjunction with upstream reservoirs and bypass systems to protect adjacent lands against flooding, and to maintain flow velocities adequate to carry out sediments that might impede navigation. Project levees in the Delta are maintained to federal standards by the State or by local landowners under state supervision.

Non-project levees are levees constructed and maintained by local reclamation districts. Non-project levees constitute about 65% of levees in the Delta flood control system. Maintaining non-project levees largely is financed by landowners, and the costs are shared with the State. Non-project levees often are maintained to widely ranging and less stringent standards than those applied to project levees.

Flood management operations are coordinated by an integrated team of representatives from federal, state, and local agencies.

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In general, reservoir water level management is governed by an approved flood control diagram. This diagram essentially defines the amount of space that should be available to store flood waters at various times of the year. Each reservoir has a unique flood control diagram that is based on the following criteria:

- The flood response characteristics of the basin.
- Agreements for the level of flood protection to be provided by the reservoir.
- Obligations for water conservation.
- Requirements necessary to maintain environmental conditions in the downstream water courses.

The primary issues of concern to upper watersheds are particular land use practices that can cause reductions in the retention and storage time of flows from the upper watershed areas, possibly resulting in increased peak runoff events and excessive erosion of hill slopes, stream banks and stream beds, and subsequent sedimentation in reservoirs.

7.8.3.1 DELTA REGION

Overview of Flood Control Development. Until the 1850s, the Delta Region was mostly a tidal marsh, part of an interconnected estuary system that included the Suisun Marsh and San Francisco Bay. During the flood season, the Delta became a great inland lake, and when the flood waters receded, the network of sloughs and channels reappeared throughout the marsh. Early settlers avoided the Delta for two reasons. First, the attempts at levee construction were hampered by high costs and lack of mechanical equipment. Second, laws were inadequate to give landowners clear title to wetlands and seasonally flooded lands. The discovery of gold at Sutter's Mill in the foothills of the Sierra Nevada resulted in a large inflow of people. The growing population increased the demand for food. Congress passed the "Arkansas Act" in 1850, which warranted title of wetlands and flooded lands to private ownership. The higher demand for food and clear ownership laws accelerated land reclamation in the Delta.

Until the 1850s, the Delta Region was mostly a tidal marsh, part of an interconnected estuary system that included the Suisun Marsh and San Francisco Bay. During the flood season, the Delta became a great inland lake, and when the flood waters receded, the network of sloughs and channels reappeared throughout the marsh.

Development of the Delta began in late 1850 when the Federal Swamp Land Act conveyed ownership of all swamp and overflow land, including Delta marshes, from the Federal Government to the State of California. Proceeds from the state's sale of swampland were to go toward reclaiming them, primarily for conversion to agricultural land.

In 1861, the State Legislature created the Board of Swamp and Overflowed Land Commissioners to manage reclamation projects. In 1866, the board's authority was transferred to county boards of supervisors. The first reclamation projects began in 1869, when developers constructed 4-foot-high by 12-foot-wide levees on Sherman and Twitchell islands using the peat soils of the Delta. Since then, levee construction has improved and expanded to 1,100 miles throughout the Delta to protect agricultural and urban lands against flooding.

Shortly after the completion of the levees in 1913, the construction of a complicated series of human-made waterways and water development facilities began in the Delta. The purpose of constructed waterways was to provide navigation, improve water circulation, or obtain material for levee construction. Water development facilities were constructed to ship water from the Delta to other parts of the State for agricultural, urban, and other uses.

Shortly after the completion of the levees in 1913, the construction of a complicated series of human-made waterways and water development facilities began in the Delta.

In the study area, the extensive levee system, constructed waterways (the Contra Costa Canal and Stockton Deep Water Channel), water development facilities, groundwater development, and railroads enabled irrigated agriculture and urban communities to extend deeper into the Delta. Between 1920 and 1950, irrigated agriculture development increased rapidly from 2.7 to over 4.7 million acres for the entire Central Valley. During the same period, urban land use also expanded. Private water development projects by cities and utility districts assisted in the expansion of urban development throughout California.

Approximately 71,000 acres of the Delta are developed for urban uses, with most of the development located on the periphery of the Delta in Sacramento, San Joaquin, and Contra Costa Counties. The majority of urban development is located in the legal Delta, with less than 1,800 acres of developed land in the Suisun Marsh and Bay Area. Urban development includes residential, commercial, industrial, and other urban uses.

Much of the urban development in the study area is located in the incorporated cities (Antioch, Brentwood, Isleton, Pittsburg, Rio Vista, and Tracy are located entirely within the Delta; and Sacramento, Stockton, and West Sacramento are located partially within the legal Delta) and the 14 unincorporated communities within the legal Delta (Discover Bay, Oakley, Bethel, Courtland, Freeport, Hood, Ryde, Walnut Grove, Byron, Terminous, Thornton, Hastings Tract, and Clarksburg).

Flood Control Facilities. The flood control facilities that currently protect the Delta Region include the following elements:

- Delta levees
- Delta Cross Channel (DCC) Control Gates
- Yolo Bypass

Flooding of reclaimed Delta lands was a frequent result of levee erosion and overtopping during high-flow events. Since construction of the CVP and SWP, the frequency of levee failure due to overtopping from flood flows has decreased. Delta levees still fail, but the most frequent cause is either high hydrostatic pressure, resulting in piping and stability failures, or overtopping due to high tides and high winds.

Flooding of reclaimed Delta lands was a frequent result of levee erosion and overtopping during high-flow events.

With the advent of the large state and federal water projects that allow more control over flood flows, flooding generally has been restricted to inundation of individual islands or tracts resulting from levee instability or overtopping. Since 1950, the construction of upstream dams has allowed dam and reservoir managers to detain flows. This management ability and control of flood waters have further reduced the threat of overtopping. Between 1950 and 1986, 60% of levee failures have been due to mass instability, commonly caused by a combination of historic subsidence and hydrostatic pressure, and 40% has been due to overtopping.

With the advent of the large state and federal water projects that allow more control over flood flows, flooding generally has been restricted to inundation of individual islands or tracts resulting from levee instability or overtopping.

The Delta levee system initially served to control island flooding during periods of high flow. Because of island subsidence due to peat oxidation, however, it is now necessary for the levee system to prevent inundation during normal runoff and tidal cycles. About 1,100 miles of levees in the Delta provide flood protection to the 76 islands and tracts located there. Figures 7.8-1a and 7.8-1b show the general locations of the federal project levees and local non-project levees in the Delta.

The major factors influencing Delta water stage include high flows, high tide, and wind. Historically, the highest water stages usually have occurred from December through February, when high runoff combines with high tides, low barometric pressure, and wind-generated waves. Flood stage elevation of rivers and channels surrounding the Delta islands generally range from 6.5 to 7.5 feet above mean sea level (msl) in the west and central Delta, where the most tidal influence is present. However, the 100-year flood stage ranges from 14.0 to 17.0 feet above msl in the north Delta (near New Hope Tract and Courtland, respectively) and in the south Delta (near Stewart Tract on the Old and Middle River channels), where the stream flows become dominant during large floods. These flood stage ranges (from 6.5 to 17.0 feet above msl) emphasize the importance of maintaining levees to varying heights and strengths throughout the Delta to protect against flooding where channel geometry and flow conditions can cause rapid stage increases during storms.

During floods, the DCC control gates prevent water from spilling out of the Sacramento River into the Mokelumne River and flooding leveed and non-leveed lands.

The DCC control gates are closed during high flows and floods on the Sacramento River. During floods, when stages on the Sacramento River exceed those on Mokelumne River channels, the gates prevent water from spilling out of the Sacramento River into the Mokelumne River and flooding leveed and non-leveed lands. If storms hit central California while the river stages are lower on the Sacramento River, the DCC gates can be opened to spill high flows out of the Mokelumne River system and reduce stages on the north and south forks of the Mokelumne River. This transfers flood water from the non-project levees of the Mokelumne River to the Sacramento River, which is protected with project levees. The SRFCP keeps the Sacramento River from flooding the Delta

Unlike the system of reservoirs and weirs that control the magnitude of flooding on the rivers upstream of the Delta, the flood control system in the Delta (aside from the DCC control gates) operates passively. However, the levee system does require maintenance, monitoring, and improvement, particularly during floods, to maximize the level of protection provided by the levee system.

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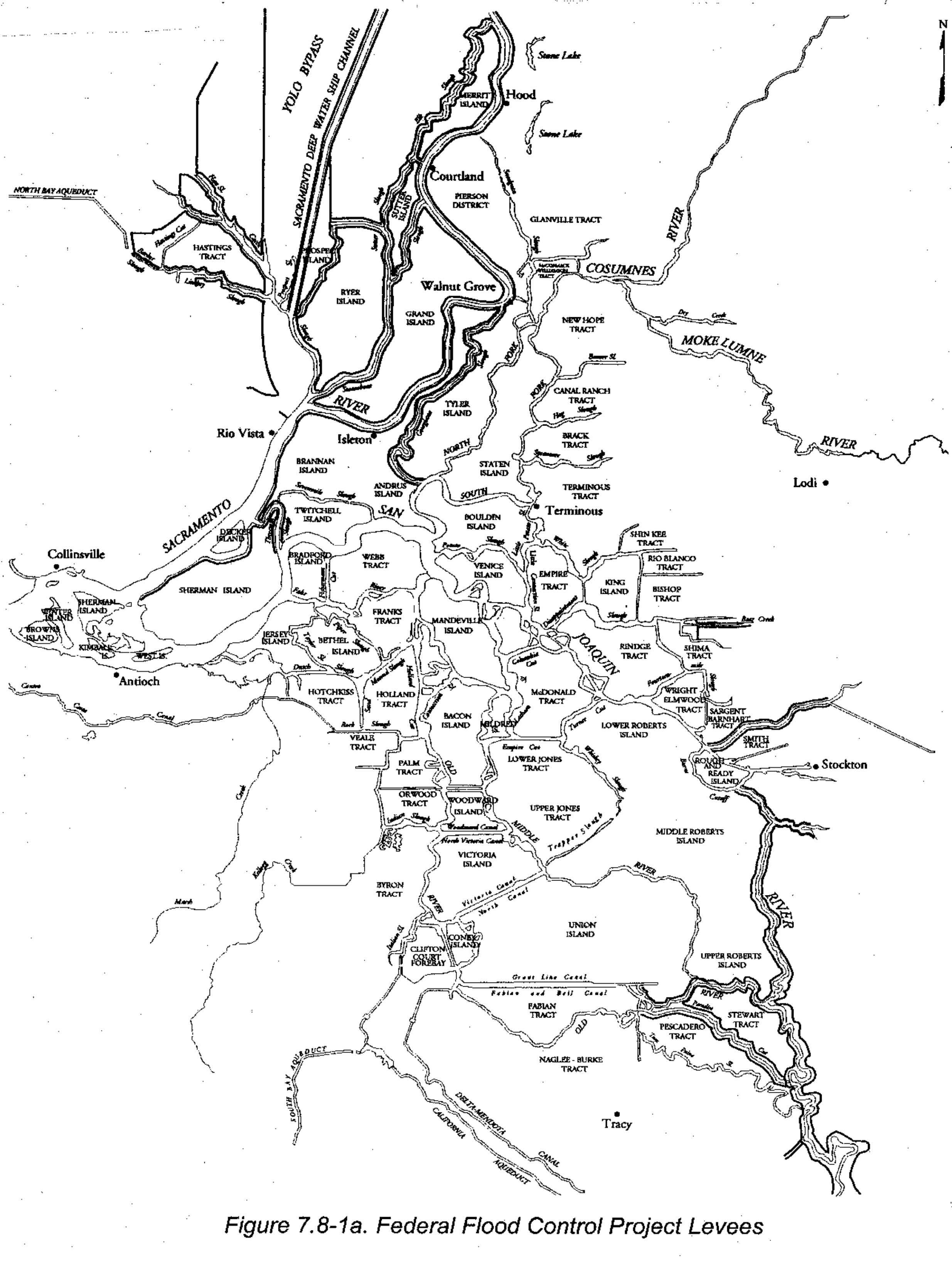

Figure 7.8-1a. Federal Flood Control Project Levees

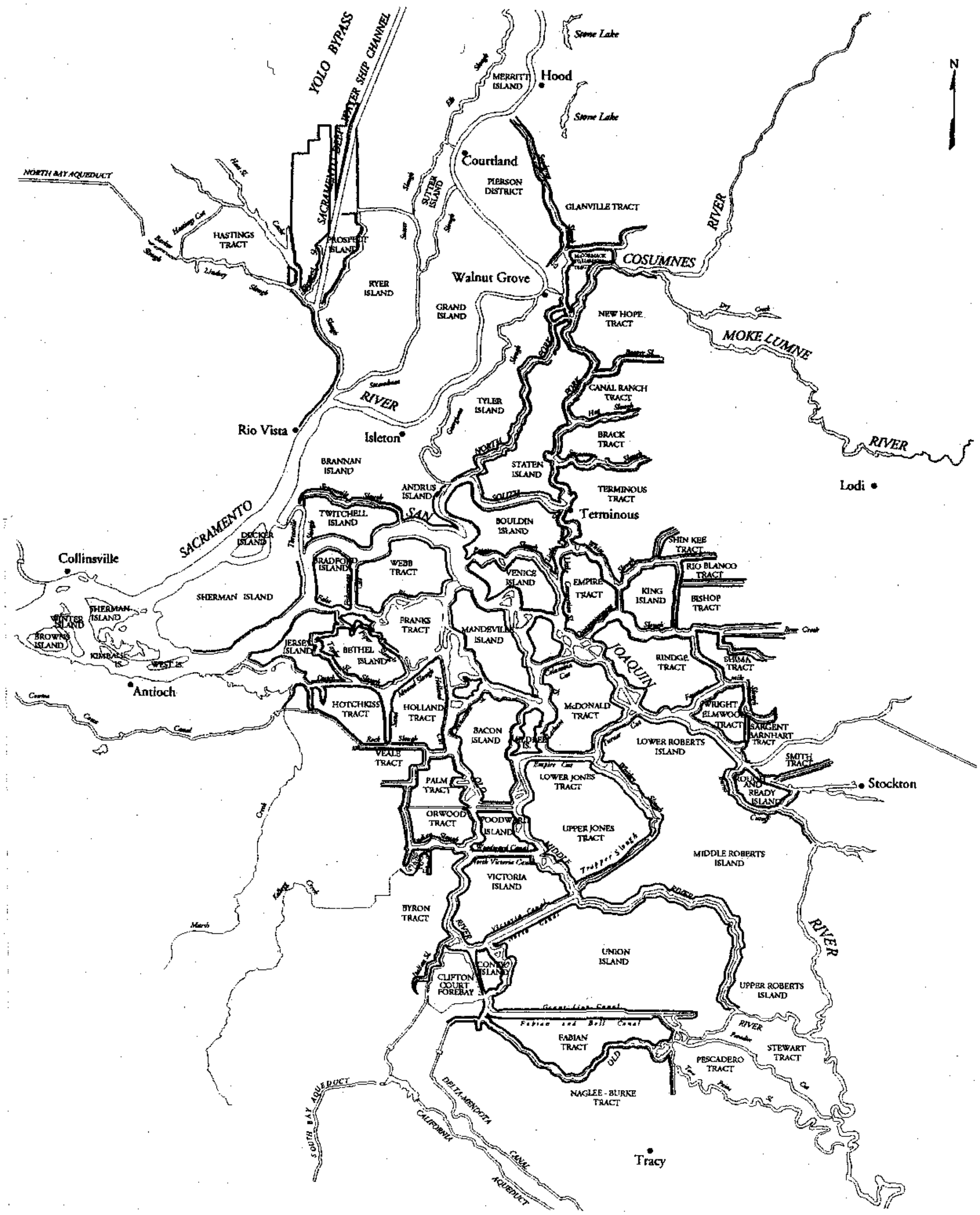

Figure 7.8-1b. Local Non-Project Levees in the Delta

Levee Stability. The stability of a levee depends on the strength of its foundation materials and its internal strength. If used in the proper proportions and engineered correctly, sands, silts, and clays can be used to build stable levees. High percentages of sands or peat within or beneath a levee, however, can weaken its stability. East Delta levees generally are supported by foundation materials composed of clay, silt, and sand; but some central and west Delta levees primarily rest on peat with some alluvial clay, bay mud, sand, and silt layers. While inorganic materials (sands, silts, and clays) provide adequate foundations, uncompressed peat is highly deformable and unstable.

Of the Delta lowlands, approximately 380,000 acres primarily consist of peat soil. When exposed to air, the peat oxidizes into a fine dust, which is easily eroded by wind and water, resulting in land subsidence. Cultivation accelerates the oxidation of peat soils. Land subsidence adjacent to the levees is a problem in the Delta because it could jeopardize the stability of the levees, which in turn, could cause flooding.

Levees can fail by three often interrelated mechanisms: overtopping, seepage and piping, and instability. Several other factors can damage levees and eventually lead to levee failure. These include erosion, seismic movements, burrowing from small mammals, wind and wave action, and dead or decaying roots from levee vegetation (living vegetation also can provide some protection against levee erosion by reducing wave and wind action). From 1950 to 1986, fifteen stability-failure floods and eight overtopping floods occurred in the region.

The Delta is subject to seismic activity from several faults. The San Andreas Fault system has the greatest potential to affect Delta seismicity. The Hayward Fault is closer to the Delta and has the second highest potential to affect Delta seismicity, with perhaps a slightly decreased level of shaking than could result from the San Andreas Fault. Other faults, including the Healdsburg-Rogers Creek Fault, Maacama Fault, Coast Range Sierra Nevada Boundary Zone, and Green Valley-Cordelia and Concord Faults, could affect Delta seismicity to a much lesser level of shaking and duration.

Since reclamation, each of the 70 major islands or tracts have flooded at least once (as shown in Table 7.8-1). About 100 failures have occurred since the early 1900s, except for Big Break, Little Franks, Franks, and Little Holland Tracts; and Little Mandeville, Lower Sherman, and Mildred Islands. Flooded islands historically have been restored even when the cost of repairs exceeded the appraised value of the land.

Flooded islands historically have been restored even when the cost of repairs exceeded the appraised value of the land.

Levee Maintenance. Costs of maintaining and repairing the levee system in the Delta are substantial. The average annual cost of levee maintenance on non-project levees in the Delta ranged from $3,000 to $165,000 per levee mile, averaging $11,800 per levee mile between 1981 and 1991. From 1981 to 1991, $63 million was spent to repair levees. Beginning in 1988, state cost-sharing authorization was increased to 75% of costs exceeding $1,000 per mile under the Delta Flood Protection Act of 1988. The act provided $60 million over 10 years to control subsidence and rehabilitate levees on eight west Delta islands and an additional $60 million for Delta-wide levee maintenance and upgrades.

Emergency expenditures by federal and state governments under the Federal Emergency Management Act (FEMA) and the Natural Disaster Assistance Act, respectively, from 1980 to 1986 was $137.3 million ($65 million FEMA, $26.5 million Natural Disaster Assistance Act, and $45.8 million by local sponsors). The cost per island acre of these repairs ranged from less than $410 to $4,000. Additionally, the Corps has spent up to $120 million in 1997 under their PL 84-99 flood fight and rehabilitation authority.

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Although flooded islands can be drained by pumping flood waters from the island after the levees are closed and reinforced, the cost can be substantial. According to DWR estimates, the total emergency cost resulting from levee failures was $97 million between 1980 and 1986. (This cost was part of the total FEMA and Natural Disaster Assistance Act costs.) In addition, Delta levee maintenance program expenditures were estimated at $64 million between 1981 and 1991.

Table 7.8-1. Historical Floods in the Sacramento-San Joaquin Delta, 1900 to 1982

YEAR	ACRES INUNDATED (1,000)
1900	12.9
1901	20.8
1902	14.7
1904	75.9
1906	63.1
1907	114.7
1908	12.4
1909	43.5
1911	9.2
1925	11.8
1926	3.4
1927	2.2
1928	8.9
1932	3.0
1936	5.1
1937	3.0
1938	19.0
1950	20.9
1955	11.5
1958	11.2
1969	10.9
1972	13.0
1980	15.7
1982	9.4

Sources:
Data for 1900 to 1958, Association of State Water Project Agencies 1976.
Data for 1969 to 1982, DWR 1984.

7.8.3.2 BAY REGION

The land in the Bay Region historically has suffered little from flooding emanating from the Sacramento-San Joaquin River system. Extensive local flooding has occurred in the Bay Region; however, this flooding has been a result of waters emanating from sources other than the Delta.

Extensive local flooding has occurred in the Bay Region; however, this flooding has been a result of waters emanating from sources other than the Delta.

Bay water is usually saline to brackish, making reclamation of the surrounding marshlands unattractive for agricultural purposes. The Suisun Marsh, located in the Bay Region, is an example of a brackish tidal marsh that was partially converted for agricultural purposes. Thus, improvements to control flooding have been minimal and now are directed mainly toward ecological habitat creation and preservation.

The broad, deep channels and large bays present downstream from the Suisun Marsh have not demonstrated significant variability in water level beyond that which occurs as a result of natural tidal fluctuations (except for sea level rise). Historical records indicate that the sea level has the potential to affect long-term flooding, water quality, and water management in the Delta. Potential sea level changes associated with climate change are discussed in Chapter 8, "Compliance with Applicable Laws, Policies, and Plans and Regulatory Framework".

The upper watersheds of the San Francisco Bay Region are characterized by small, steeply sloping watersheds, and rapid runoff. The eastern slopes of the coastal hills once contained redwood forests that were largely logged off by the end of the nineteenth century. Most of the urban development and road building in upland areas has occurred since World War II.

The upper watersheds of the San Francisco Bay Region are characterized by small, steeply sloping watersheds, and rapid runoff.

Average annual precipitation in the upper watershed areas ranges from 25 to 50 inches. Average annual runoff ranges from 10 to 20 inches. Flooding generally is confined to reclaimed marshland along the Bay margin and occurs when high-runoff conditions are combined with high tides in the Bay. Besides direct flooding, flood-related problems include insufficient capacity of some municipal wastewater treatment plants that must discharge to the Bay.

No significant flood control resources are at work in the Bay Region to control floods emanating from the Delta. The Suisun Marsh Salinity control gates project was implemented in 1988. The gate system works primarily to protect the marsh from the saline waters of the Bay during periods of low Delta outflows. The Suisun Marsh salinity control gates do not play a specific role in flood control but are part of the affected environment that should be considered during Program solution evaluation.

7.8.3.3 SACRAMENTO RIVER REGION

Overview of Flood Control Development. The bottomlands of the Sacramento River Region consisted of tule marshlands prior to the Gold Rush of the mid-nineteenth century. Before the beginning of agricultural development in the Sacramento Valley, large portions of the valley were subject to periodic inundation by flood flows from the Sacramento River and its tributaries. The floodplain varied in width from 2 to 30 miles.

Historically, large portions of the Sacramento Valley were subject to periodic inundation by flood flows from the Sacramento River and its tributaries. The floodplain varied in width from 2 to 30 miles.

Individual landowners began flood control system development in the mid-1800s, when the Gold Rush increased demands for food. By 1884, many miles of levees had been completed, and some areas had formed flood protection districts. These first levees were constructed by hand and were demonstratively inadequate, based on the damage that occurred during high-flow periods.

This damage was exacerbated by hydraulic mining in the mountains. The mining activities resulted in large volumes of silt, sand, and gravel being deposited into the rivers of the Sacramento Basin. These sediments were deposited in the channels and increased the flood stages associated with high-flow events by reducing channel capacity.

Federal flood control activities were initiated in 1917 when Congress authorized the SRFCP. This project consisted of a comprehensive system of levees, overflow weirs, outfall gates, pumping plants, leveed bypass floodways, overland floodway areas, enlarged and improved channels, and dredging in the lower reach of the Sacramento River. The effectiveness of the SRFCP was increased by the completion of multi-purpose reservoirs that provide flood control storage. The reduction of the flood hazard has encouraged extensive development in the protected areas and has prevented billions of dollars in flood damage since project completion.

This Sacramento River Flood Control Project consisted of a comprehensive system of levees, overflow weirs, outfall gates, pumping plants, leveed bypass floodways, overland floodway areas, enlarged and improved channels, and dredging in the lower reach of the Sacramento River.

Flood Control Facilities. Multi-purpose reservoirs and a system of weirs and bypasses contribute to the flood control system in the Sacramento Basin by storing or diverting water during periods of high runoff, thereby reducing the ultimate load placed on the levee system during floods. Levees also provide flood control in the region.

Multi-purpose reservoirs and a system of weirs and bypasses contribute to the flood control system in the Sacramento Basin by storing or diverting water during periods of high runoff, thereby reducing the ultimate load placed on the levee system during floods.

Stability issues affecting the project levees in the Sacramento River Region include settlement, erosion, and seepage. These issues are the same as those described for the Delta Region; additional detail may be found in the Flood Control Technical Report.

Although non-project levees are present in the Sacramento River Region, these levees do not substantially affect the overall level of flood protection.

Major reservoirs that provide flood protection to the Sacramento River Region are:

- Folsom Lake
- Lake Oroville
- Shasta Lake

Other important reservoirs include:

- Black Butte Reservoir
- Camp Far West Reservoir
- Union Valley Reservoir
- French Meadows Reservoir
- Clear Lake
- East Park Reservoir
- Englebright Reservoir
- Lake Almanor
- New Bullards Bar Reservoir
- Rollins Reservoir
- Stony Gorge Reservoir
- Whiskeytown Reservoir
- Berryessa Reservoir

The reservoirs were constructed and are maintained by state, federal, and local agencies that cooperate in their funding, administration, operation, and maintenance.

A system of weirs and bypasses was constructed by the Corps on the Sacramento River. The system includes five bypasses: the Butte Basin, Sutter Bypass, Yolo Bypass, Tisdale Bypass, and Sacramento Bypass. Moulton and Colusa Weirs feed flood waters into the Butte Basin Bypass, Tisdale Weir flows into Sutter Bypass, and Fremont Weir and Sacramento Bypass flow into the Yolo Bypass.

The Yolo Bypass carries five-sixths of the volume of the Sacramento River at peak flood flows. The lower end of the bypass is in the Delta and provides significant spawning habitat for Delta smelt.

The bypasses are large tracts of undeveloped or minimally developed land. Development within the bypasses typically is limited to agricultural activities that require minimal infrastructure. Water released to the bypass system flows south into the Delta, in effect creating a short-term storage system for the flood waters. Additionally, a significant volume of the water released to the bypass system infiltrates into the ground, recharging groundwater supplies, although this volume is small compared to the total volume of a flood.

Water released to the bypass system flows south into the Delta, in effect creating a short-term storage system for the flood waters. The weir system works by diverting flood waters in the leveed rivers into the bypasses.

When a flood occurs, reservoirs can restrain the high-volume flows and store water for later release back into the river. The system allows flood waters to be transported downstream in a controlled manner starting days before and continuing until weeks after a flood.

By varying the amount of water kept in reservoirs during different times of the year, the system can be modified to maximize flood control capabilities during the early part of the flood season and to maximize water storage later as the flood risk abates. The water stored in the reservoirs can be used to maintain fisheries flows during dry periods and supply power to municipalities and industries.

When flooding occurs, the weir and bypass system diverts water to protect the levee system and frees flood storage capacity in the reservoirs. The weir system works by diverting flood waters in the leveed rivers into the bypasses.

Upper Watershed Areas. In the upper watersheds of the Sacramento River Region, fire historically has been the principal mechanism by which nutrients in forest material were recycled. However, since the late 1800s, the frequency of fires has been reduced in the upper watershed, with the effect that less frequent fires burn larger areas with higher intensity and greater environmental damage. Catastrophic wildfires produce more intensive and extensive changes in watershed conditions that any other form of disturbance. As a consequence of fire suppression and logging practices during the last century, the character of forests has changed dramatically, and there has been a large increase in dead wood fuels near the forest floor. Severe fires accelerate runoff from the watershed by reducing organic matter in soil and forming impervious soil layers.

Catastrophic wildfires produce more intensive and extensive changes in upper watershed conditions that any other form of disturbance.

Improper location and construction of roads and culverts may be the most significant cause of accelerated erosion in western montane forests.

Improper location and construction of roads and culverts may be the most significant cause of accelerated erosion in western montane forests.

Past grazing policies also may have affected land in the Sierra Nevada. Loss of streamside vegetation from grazing has promoted soil compaction and erosion. Removal of riparian vegetation by livestock in headwater valleys of the North Fork Feather River, for example, has led to rapid channel widening and massive sediment loads.

Rapid runoff due to poor timber and grazing practices, combined with increased urban development, has increased the local flood hazard and exposure in some upper watershed areas. Accelerated erosion increases the rate of reservoir sedimentation, reducing reservoir capacities available for flood control downstream.

7.8.3.4 San Joaquin River Region

Work on flood control projects in the San Joaquin River Region began early in the twentieth century. Improvements have included the construction of levees and bypasses, maintenance or improvement of stream channels, and completion of a system of reservoirs. These projects have been completed primarily to provide flood control and to augment agricultural opportunities.

The flood control resources currently employed in the San Joaquin River Region include levees, reservoirs, weirs, and bypasses.

On many of the tributaries, such as the Stanislaus River, non-project levees are very important for the flood system.

Stability issues affecting the project levees in the San Joaquin River basin include settlement, erosion, and seepage. One major issue for the San Joaquin River system is inadequate flood carriage capacity. On many of the tributaries, such as the Stanislaus River, non-project levees are very important for the flood system.

Reconnaissance studies conducted by the Corps on levees on both banks of the San Joaquin River, from Friant Dam downstream to Old River, Mariposa Bypass, Eastside Bypass, and Chowchilla Bypass, indicated that materials used to construct levees on the San Joaquin River mainstem generally range from clay to silty sand. Evaluations of levee reaches ranged from "fair" to "acceptable and well maintained" to "good." Overall, the flood control project features were summarized as "adequate." The primary problem is a lack of maintenance. Local bank protection is needed. Setback levees in some reaches may be needed in the future. Because the levees were inspected during relatively low summer water levels, seepage conditions could not be fully evaluated.

The primary problem for levees in the San Joaquin River Region is a lack of maintenance. Local bank protection is needed. Setback levees in some reaches may be needed in the future.

Major reservoirs that protect the San Joaquin River Basin from floods include:

- Hensley Lake
- H. V. Eastman Lake
- New Exchequer Reservoir

- New Melones Lake
- Friant Reservoir
- Terminus Reservoir
- Success Reservoir
- Pine Flat Lake
- Tuolumne River Reservoir (Cherry Valley and New Don Pedro Lakes)

A system of weirs and bypasses has been established on the San Joaquin River system. The system includes three bypasses (the Mariposa, Eastside, and Chowchilla Bypasses) fed by weirs. The San Joaquin River bypass system operates similarly to the Sacramento River bypass system during flood events.

A system of weirs and bypasses has been established on the San Joaquin River system.

The levee and reservoir system in the San Joaquin River basin is operated to control floods with the same methods described for the Sacramento River Region. Historically, the San Joaquin Valley basin has been subject to floods occurring during late fall and winter, primarily as a result of prolonged rainstorms; and to floods occurring during spring and early summer months, primarily as a result of unseasonable and rapid melting of the winter snowpack in the Sierra Nevada.

7.8.3.5 Other SWP and CVP Service Areas

The Other SWP and CVP Service Areas region includes two distinct, noncontiguous areas: in the north, are the San Felipe Division's CVP service area and the South Bay SWP service area; to the south, are the SWP service areas. The northern section of this region encompasses parts of the central coast counties of Santa Clara, San Benito, Santa Cruz, and Monterey. The southern portion includes parts of Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura Counties.

No Program alternative includes actions that would significantly affect flood control resources in the Other SWP and CVP Service Areas.

No Program alternative includes actions that would significantly affect flood control resources in the Other SWP and CVP Service Areas. If new storage or conveyance facilities are constructed under the Program alternatives, their operations would be integrated with current flood control operations criteria for existing facilities in the region. No further discussion of this region is included in this section.

7.8.4 Assessment Methods

To provide an additional measure of the relative flood control importance of Program actions, data on large flood events in the Sacramento and San Joaquin Rivers were used in the assessment.

The discussion of assessment methods is separated into three sections: flood management operations, levee system, and flood control economics. The flood management operations discussion focuses on the flood control system's ability to handle flood flows under the project alternatives from a conveyance and storage perspective. The analysis of the levee system focuses on the system's ability to handle the flood flows from a structural perspective. The economics of flood control compares flood control benefits with flood control costs.

For those Program actions that generally involve north Delta modifications, the North Delta Program Draft EIR/EIS was reviewed. Flows and elevations from the 1984 flood and a predicted 100-year flood were analyzed. For the south Delta modifications, the Interim South Delta Program (ISDP) EIR/EIS was reviewed.

To provide an additional measure of the relative flood control importance of Program actions, data on large flood events in the Sacramento and San Joaquin Rivers were used. For the Sacramento River, daily flow data from the February 1986 flood were used. For the San Joaquin River, daily flow data from the floods of 1980, 1983, and 1997 were used. For each alternative, proposed additions to storage were compared to the measured flood flows for these large events. These comparisons then were used to determine whether the additional storage proposed for each alternative would substantially increase flood management capabilities relative to expected flood flows.

Simulated changes in conveyance capacity resulting from channel widening were analyzed using the Corps' HEC-RAS model. This model simulates water surface elevations for a given channel geometry and flow rate. Using this model, different channel configurations in the alternatives were compared to the base case to determine whether these configurations would significantly change conveyance capacity in the potentially affected channels.

Potential impacts on the levee system were assessed by literature reviews and interviews with geotechnical specialists to develop the existing conditions and No Action Alternative trends, and to identify potential impacts and mitigation strategies.

Flood control benefits are damages and losses avoided in the future that are expected as a result of the flood control project. Flood control costs are those necessary to implement and maintain the project under evaluation. Costs generally are well determined for specific flood control projects for which engineering design studies have been completed. Benefits, however, must be estimated because they depend on the improved performance of the levee to prevent future damages to agriculture (soils and crops) and buildings or facilities. The timing and severity of flood events also must be estimated to determine benefits.

Direct benefits include avoided damages to soils, ecosystem habitat, crops, buildings and their contents, and infrastructure; avoided functional losses, including building rent; avoided business income losses; avoided emergency response costs; avoided loss of life; and avoided loss of public and nonprofit services. Benefits are those expected future benefits that are estimated over the useful lifetime of the flood control project and discounted to present values.

Flood control benefits are damages and losses avoided in the future that are expected as a result of the flood control project.

Direct benefits include avoided damages to soils, ecosystem habitat, crops, buildings and their contents, and infrastructure; avoided functional losses, including building rent; avoided business income losses; avoided emergency response costs; avoided loss of life; and avoided loss of public and nonprofit services.

Procedures for the economic assessment of flood control impacts include:

- An inventory and estimated values of land, crops, buildings, associated uses, and infrastructure.

- Estimates of the effectiveness of the project to reduce damages and functional losses.

- Estimates of the flood risk associated with the project.

Secondary economic benefits and costs also arise from flood control projects. Secondary economic effects result when local firms purchase production inputs and sell products to other firms in the region. Indicators of secondary benefits (and costs) are changes in related asset values, incomes, employment, tax revenues, the cost of providing public services, and population. Secondary economic benefits and costs can be calculated using existing data after the direct economic effects are estimated.

Secondary economic benefits and costs also arise from flood control projects.

7.8.5 SIGNIFICANCE CRITERIA

The description of flood management system impacts is qualitative because of the general level of definition of the programmatic alternatives.

For this analysis, an impact on flood management system operations is considered significant if a Program action has the potential to:

- Raise flood stage elevations
- Increase the frequency of flooding

An impact on flood management system operations is considered less than significant if a Program action would not:

- Substantially raise flood stage elevations
- Increase the frequency of flooding.

An impact on the levee system is considered potentially significant if a Program action would substantially increase any of the following:

- Seepage
- Levee settlement
- Wind erosion
- Flood stage hazards
- Scour
- Sedimentation
- Subsidence adjacent to levees

In addition, an impact on the levee system is considered potentially significant if a Program action would substantially decrease any of the following:

- Levee stability
- Inspection, maintenance, or repair capabilities
- Levee slope protection
- Emergency response capabilities
- Channel capacity
- The ability of levees to withstand seismic loading

Changes that exceed 10% in either costs of flood control or expected benefits are considered potentially significant (adverse and beneficial, respectively) for this analysis.

Economic criteria can be used to judge the significance of physical changes to the environment. Costs and expected benefits are described for each alternative and quantified where possible. Changes that exceed 10% in either costs of flood control or expected benefits are considered potentially significant (adverse and beneficial, respectively) for this analysis.

The expected annual cost of levee failure is an indication of potential flood control benefits

Values for the significant flood control parameters were projected for the No Action Alternative and the four proposed alternatives. These values then were used to develop the expected annual cost of levee failure and the annual cost of flood protection. The expected annual cost of levee failure is an indication of potential flood control benefits, assuming that the levee system is 100% effective to the design elevation. The annual cost of flood protection represents the level of effort with the assumption that levees would be effective to their designed level of effectiveness. An annual cost of $15 million is used. If the flood protection program was 100% effective, the benefit cost ratio for the program could be calculated by dividing the annual potential benefits by the annual cost.

7.8.6 NO ACTION ALTERNATIVE

7.8.6.1 DELTA REGION

Under the No Action Alternative, continued deterioration of the levees and diminished ability to handle flood flows are expected. As with other public infrastructure, funding is inadequate to eliminate the maintenance backlog. The inadequacy of funding is expected to continue.

The inability to compete for limited funding could cause some participants to delay or forego paying for levee repairs.

The inability to compete for limited funding could cause some participants to delay or forego paying for levee repairs. As more participants delay repairs, more levees could deteriorate, resulting in decreases in overall levee system stability and integrity. It is likely that some Delta islands with less capital improvements would not be reclaimed if they became flooded due to levee failures, resulting in lost habitat and water quality resources.

Much of the immediately foreseeable levee improvement funding is expected to be spent for levee stability and habitat improvements to protect valuable economic, water quality, and habitat resources. Levees surrounding west Delta islands define major Delta channels in the area where fresh water and salt water mixes. Levee failure and island flooding could result in undesirable salt-water intrusion and other adverse water quality impacts.

In other locations, funding could be adequate to improve existing levees or to construct new ones. For example, levee assessments and funding may increase in areas where urbanization continues. Levees could be eligible for federal funds as part of cost sharing for post-flood assistance if they have been: (1) maintained to the PL 84-99 criteria requiring that levees be restored to the geometry and level of protection provided prior to a flood event, and (2) approved prior to a flood that has been declared a national disaster.

Residents and users of new developments could accelerate levee deterioration through increased access, erosion induced by boat wakes, and vandalism.

Physical processes cause gradual deterioration of levees and increased pressures on the levees. These processes include settlement, erosion from waves and current scour, burrowing from small mammals, internal levee and foundation erosion, and subsidence adjacent to the levee. All of these processes could lead to an increased risk of levee overtopping and stability failures, especially during flood events.

As levee deterioration continues under the No Action Alternative, the ability of the system to handle peak flows would be increasingly jeopardized. In addition, long-term settlement of levees due to ongoing consolidation or migration of foundation soils, especially peat, would reduce the levees' crest elevation. Scour and erosion could cause loss of levee material. If supporting material is lost at the base, or water-side "toe," of a levee slope, stability failures could result. Internal erosion, or piping, is frequently exacerbated by animal burrows and decaying tree roots, which also could lead to instability or overtopping. Deterioration of levee systems and subsidence would continue.

Delta dredging is limited to 45 days (from August 1 to September 15) by regulatory constraints and species considerations, making the Delta a limited source of dredged borrow material. Timing of future Delta dredging is expected to remain limited.

Delta dredging is limited to 45 days (from August 1 to September 15) by regulatory constraints and species considerations.

Coordinated habitat restoration efforts probably would continue. Senate Bill (SB) 1065, enacted in 1991 (California Water Code Sections 12306 and 12307), required habitat protection as part of levee maintenance work. SB 1065 directed future mitigation associated with levee maintenance to result in no net long-term loss of habitat. California Water Code Section 12987(d) requires DFG to make a written determination, as part of its review and approval of a plan or project, that program expenditures are consistent with a net long-term habitat improvement program and result in a net benefit for aquatic species in the Delta.

Urbanization pressures from the perimeter of the Delta Region could continue. Residents and users of new developments could accelerate levee deterioration through increased access, erosion induced by boat wakes, and vandalism (for example, unauthorized recreational driving on levee slopes and disturbance or removal of rock protection). As urbanization continues in and around the Delta, and near its tributary streams and rivers, runoff is expected to increase. Increased runoff could lead to increased river stage in the Delta.

The overall effect of the interim reoperation of Folsom Dam and Reservoir on the Delta flood control system is beneficial. Interim reoperation delays the timing of flood flows and consequently reduces the possibility that flood peaks from the American River watershed could reach the Delta. Interim reoperation of Folsom Dam and Reservoir could continue to require release of more water than usual in fall to create reservoir space for spring runoff from the American River watershed. The ability of Folsom Dam and Reservoir to detain a much greater volume of runoff than has been historically possible under traditional flood-curve operating criteria is important. During a flood, detention could allow flood managers to maintain safe flows on the American River through the city of Sacramento to its confluence with the Sacramento River. The reoperation, however, increases the risk of not filling Folsom Lake, reducing the available water supply.

The overall effect of the interim reoperation of Folsom Dam and Reservoir on the Delta flood control system is beneficial.

Levee reconstruction along the Sacramento River and the Colusa Basin Drain as a part of the SRFCP could reduce the risk of flood stage hazards in the Delta Region. However, some accidental upstream levee failures have acted as beneficial safety valves by unintentionally causing the release of waters before they could have otherwise flooded the Delta. After these accidental upstream releases, the reduced flow volume in the Sacramento River channel resulted in lower flood stages and hazards in the Delta. Future flood risk hazards in the Delta therefore could increase if upstream levee repairs are made at these "safety valve" locations before repairs are made to downstream Delta levees.

Future flood risk hazards in the Delta could increase if upstream levee repairs are made at "safety valve" locations before repairs are made to downstream Delta levees.

Flood control projects implemented upstream of the Delta could result in hydraulic impacts on Delta levees.

The occurrence of the Loma Prieta Earthquake in 1989 has intensified concerns relating to the stability of levees in the Sacramento-San Joaquin Delta. DWR has provided preliminary assessments of the susceptibility of Delta levees to damage from future earthquakes and an evaluation of the opportunity for that damage to occur.

The real value of land, buildings, and related contents is estimated to increase by 25% in all use categories by 2020 (see Table 7.8-2). This increase is based on extrapolation of recent trends in land uses, including increased orchard and vineyard acreage and more intensive residential, commercial, and recreational uses. The value of habitat, wetland, open water, and annual expected flood losses also are projected to increase by 25%. The annual cost of flood prevention, which is measured in the State Subvention Program expenditures, is assumed to remain constant.

Under the No Action Alternative, land and property values in the Delta Region are expected to increase, but flood protection levels would slightly decline. The Delta Region may experience up to $400 million in annual losses to land and property from flooding. Ongoing programs would provide increased levels of flood protection in the Sacramento River and San Joaquin River Regions, but these regions also may contain an increased value of resources at risk of flooding.

Table 7.8-2. Delta Region Existing and Future Values of Potentially Affected Resources for the No Action Alternative

FLOOD CONTROL ECONOMICS PARAMETER	EXISTING CONDITIONS		NO ACTION ALTERNATIVE	
	ASSUMPTIONS	VALUES	ASSUMPTIONS	VALUES
Residential land values	5k acres @ $20,000	$100,000,000	25%	$125,000,000
Commercial land values	2k acres @ $30,000	$6,000,000	25%	$7,500,000
Industrial land values	6k acres @ $10,000	$60,000,000	25%	$75,000,000
Irrigated land	465k acres @ $3,000	$1,395,000,000	25%	$1,743,750,000
Nonirrigated land	90k acres @ $1,000	$90,000,000	25%	$112,500,000
Residential building and contents values	5k acres @ $200,000	$1,000,000,000	25%	$1,250,000,000
Commercial building and contents values	2k acres @ $300,000	$600,000,000	25%	$750,000,000
Industrial building and contents values	6k acres @ $100,000	$600,000,000	25%	$750,000,000
Agricultural building and contents values	550k acres @ $750	$412,500,000	25%	$515,625,000
Infrastructure value	60k acres @ $100,000	$6,000,000,000	25%	$7,500,000,000
Native vegetation	35k acres @ $1,000	$35,000,000	0%	$35,000,000
Riparian and wetland vegetation	100k acres @ $3,000	$300,000,000	0%	$300,000,000
Open water	90k acres @ $3,000	$270,000,000	0%	$270,000,000
Expected annual cost of levee failure	3% * total value	$317,955,000	25%	$397,443,750
Annual cost of flood protection	Average state subvention costs in Delta	$10,000,000	0%	$10,000,000

Note:
k = thousand (,000)

It is likely that several levee failures would occur between now and 2020, and that some of these levees may not be repaired. This would reduce the value of property remaining to protect in 2020. In addition, when levees fail, adjacent islands are threatened due to increased wind fetch and seepage, which could lead to more levee failures.

7.8.6.2 BAY REGION

Existing flood control resources and those associated with the No Action Alternative are, with few exceptions, located upstream of the Bay Region and would not affect flood control in the Bay Region.

Existing flood control resources and those associated with the No Action Alternative generally are located upstream of the Bay Region and would not affect flood control in the region.

7.8.6.3 SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

The Sacramento River and San Joaquin River Regions include a large amount of flood-prone lands upstream of the statutory Delta on the Sacramento and San Joaquin Rivers and their tributaries. Assessments of flood control needs and potential actions currently are being conducted by the Corps. It is anticipated that some or many of these actions will be undertaken between now and 2020, but specific projects and their impacts on flood control economics have not been identified. Therefore, some improvement in flood control protection and reduction of risk in these regions is likely between now and 2020.

Concurrently, the real value of resources susceptible to flood damage is expected to increase. Trends causing the increase include the long-term shift toward permanent and vegetable crops, continued residential and other urban development, and increased demand for recreational and environmental resources. Costs of flood protection also are expected to increase. Both regions contain a wide range of flood control resources including levees, weirs, bypasses, and reservoirs.

The levees in the Sacramento River and San Joaquin River Regions are subjected to five forces that affect their performance: settlement, slope stability, overtopping, seepage, and erosion.

Current maintenance and repair policies are assumed to continue through 2020. With this assumption, the levees can be expected to perform adequately through 2020. The levees in the Sacramento River and San Joaquin River Regions are subjected to five forces that affect their performance: settlement, slope stability, overtopping, seepage, and erosion. In general, these forces can be handled through the currently authorized maintenance and emergency response mechanisms.

Weirs and bypasses are covered by federal and state agreements, and would continue to operate under the No Action Alternative as they do today. Likewise, the reservoirs are covered under a variety of federal, state, and cooperative agreements that ensure their effective operation through 2020.

7.8.7 CONSEQUENCES: PROGRAM ELEMENTS COMMON TO ALL ALTERNATIVES

All alternatives are expected to increase the value of agri-ultural land due to more abundant irri-gation water and better flood control.

For flood control, the environmental consequences of the Ecosystem Restoration, Water Quality, Levee System Integrity, Water Use Efficiency, Water Transfer, and Watershed Programs, and the Storage element elements are similar under all Program alternatives, as described below. The environmental consequences of the Conveyance element vary among Program alternatives, as discussed in Section 7.8.8.

7.8.7.1 ALL REGIONS

Most of the economic benefits of flood control are embodied in the provisions of the Ecosystem Restoration Program and in the Levee System Integrity Program, with the specific objective to improve all levees to PL 84-99 standards. Generally, the alternatives are projected to increase the acreage of native vegetation, riparian and wetland habitat, and open water at the expense of agricultural land. The values of commercial, industrial, and residential land are projected to increase slightly due to improved flood control effectiveness.

All alternatives are expected to increase the value of agricultural land due to better flood control.

7.8.7.2 DELTA REGION

Ecosystem Restoration Program

Reduced levee and berm vegetation management practices may result in significant and adverse long-term impacts on levee stability. Reduced pruning and clearing would allow more deep roots to penetrate levees and more dense vegetative canopies on levee surfaces. Dense vegetation could substantially reduce inspection capabilities by hiding rodent holes, cracks, or other potential causes of levee degradation. Thick understory vegetation also would limit access to levee side slopes, thereby reducing maintenance, repair, and emergency response capabilities.

Ecosystem Restoration Program actions in the Delta Region may result in potentially significant impacts related to levee stability, increased seepage, and increased wind-fetch and wave erosion.

Habitat restoration using conservation easements along riparian corridors could significantly and adversely reduce levee stability. Over time, deep-rooted and dense riparian trees and shrubs could increase the opportunity for roots to penetrate levees. Increased cracking and fissures could allow water to enter the levee interior, resulting in reduced structural stability. Small cracks, fissures, and root voids also could allow increased seepage beneath the levee, which could increase levee instability.

Reduced shallow flooding of Delta islands susceptible to subsidence could significantly and adversely increase seepage on adjacent islands, and lead to substantial flooding from seepage-induced failure. The amount of seepage depends on soil permeability, seepage paths through the levee and its foundation, and the water stage.

Setback levees, conversion to wetlands, widened floodplains, and restoration of shallow-water habitat would benefit the flood control system.

Island flooding results in significant increases in wind-fetch and wave erosion on landside levee slopes. Waterside slopes also could experience significant erosion from increased wind-fetch and waves if the existing levees are not left intact. Erosion may be a gradual problem with impacts not detected until a significant amount of levee slope material has been removed.

Under the Ecosystem Restoration Program, the construction of new setback levees to increase the conveyance of selected Delta channels would have a beneficial impact on flood control.

The construction of overflow basins and conversion of levee lands to wetlands would reduce peak flood flows to areas downstream of the overflow basins. The sizes of the overflow basins have not yet been determined; therefore, the reduction in flood flows cannot be quantified. However, given the flood sizes that have occurred in the north Delta, the impacts on the flood control system are expected to be small or localized unless sufficient area is made available for flood storage.

Using setback levees, widening and providing floodplain areas along Delta channels would increase channel water conveyance capacity in new overflow basins or wetland areas, resulting in a beneficial impact on the flood control system. The relative impacts would be minor on large channels and greater on small channels.

Increased density of shallow-rooted grasses and vegetation could beneficially increase erosion protection on levee side slopes. Shallow roots protect levees against erosion by binding soil particles.

Establishing and enforcing no-wake boating zones would beneficially affect the flood control system by reducing wave run-up and erosion.

Establishing and enforcing no-wake boating zones would benefit the flood control system by reducing wave run-up and erosion.

Restoration of shallow-water habitat would result in beneficial long-term impacts on Delta levee stability. Flooding islands with elevations below sea level would reduce the oxidation rates of peat soils, which would reduce settlement and related flood-stage hazard risks.

Urban and industrial runoff control measures could provide slight flood control benefits. Design of storm drainage systems targeting maximum stormwater infiltration or stormwater sedimentation facilities would beneficially affect the Delta flood control system. Increased detention and infiltration would reduce the volume of surface flooding. Although stormwater basins would not detain substantial volumes of flood waters, their storage function could slightly reduce local flood-stage hazard risks.

Mitigation is available to reduce all potentially significant adverse impacts on flood control associated with the Ecosystem Restoration Program in the Delta Region to less-than-significant levels.

Mitigation is available to reduce all potentially significant adverse impacts on flood control that are associated with the Ecosystem Restoration Program in the Delta Region to less-than-significant levels.

Water Quality Program

No adverse effects on flood control in the Delta Region are anticipated from Water Quality Program actions. A slight local flood control benefit could occur from reductions in urban and industrial runoff.

Levee System Integrity Program

Raising levee heights, widening levee crowns, flattening levee slopes, and constructing stability berms as part of the Delta Levee Base-Level Protection and Special Improvement Plans would improve Delta levee system stability. When levees meet PL 84-99 criteria, they may qualify for post-flood federal funding assistance.

Providing slope protection, relocating irrigation ditches, and installing drainage systems or slurry cut-off walls as part of the Delta Levee Base-Level Protection Plan would improve Delta levees by reducing erosion and seepage. Implementing these actions in compliance with uniform levee maintenance criteria and uniform guidelines for habitat enhancement and protection would reduce degradation of the levee system and prevent long-term habitat loss.

Improving channel configurations for flood flows, constructing cut-off levees, and creating bypass systems consistent with Delta levee special improvement projects would benefit system flood conveyance capacity by allowing flood inflows to safely pass into the Delta. Improved flood flow conveyance capacity into the Delta would reduce the incidence of instability and overtopping failures in the north Delta.

Easements and less-intense agricultural practices, as non-structural improvements to the flood control system, would not adversely affect ecosystem restoration activities.

Purchasing conservation easements adjacent to levees and reducing the intensity of agricultural practices near landside levee slopes as part of the Delta Island Subsidence Control Plan would improve levee stability by reducing subsidence. Easements and less-intense agricultural practices, as nonstructural improvements to the flood control system, would not adversely affect ecosystem restoration activities.

Preparing updated flood risk assessments and arranging for advance equipment contracts, participation agreements, and levee repair materials as part of the Delta Levee Emergency Management Plan would improve flood control system integrity by reducing levees' vulnerability to catastrophic failure. Improved emergency preparedness through multi-agency participation would minimize the extent and severity of flood damage and thereby reduce post-disaster recovery funding needed from FEMA and other disaster-relief agencies.

Preparing updated seismic risk assessments and ground motion mapping, and performing dynamic testing of levee material properties and levee stability analysis would improve the understanding of Delta levee performance during an earthquake.

Preparing updated seismic risk assessments and ground motion mapping, and performing dynamic testing of levee material properties and levee stability analysis would improve the understanding of Delta levee performance during an earthquake. This improved understanding would allow preliminary identification of the locations where levees may be most susceptible to earthquake damage, which could guide future cost-effective expenditure of funds used for strengthening those levees most susceptible to failure during an earthquake.

Special levee stabilization projects based on island resources could beneficially affect the Delta flood control system. Habitat improvement and levee stabilization projects could be implemented according to their potential to improve Delta water quality, agricultural production, life and personal property, recreation, cultural resources, ecosystem, infrastructure, and adjacent island functions and values. These projects could improve levee stability, increase freeboard, and reduce scour and seepage potential at important locations throughout the Delta Region. Existing levees could be rehabilitated and set back in some locations to make these improvements.

Other than in the Bay Region, the Levee System Integrity Program is not addressed under the region-specific discussions that follow.

Water Use Efficiency Program

No actions in the Water Use Efficiency Program would significantly affect the flood control system in the Delta Region.

Water Transfer Program

Generally, the actions in the Water Transfer Program would not substantially affect the flood control system in the Delta. A specific water transfer could result in beneficial or adverse impacts on flood control, depending on the source of water for the transfer and the timing, magnitude, and pathway of each transfer. If a transfer involves releasing water from a reservoir during summer, additional space to store inflow and reduce the threat of downstream flood flows may result.

Impacts from water transfers depend on the source of water for the transfer and the timing, magnitude, and pathway of each transfer.

Watershed Program

No adverse impacts on flood control are anticipated in the Delta Region from Watershed Program actions. Local flood control resources could benefit from Program actions that restore water retention features of watersheds, such as revegetation and runoff control. Some benefits could be substantial, such as sediment reduction and increased storage capacity.

Storage

For actions involving increased storage, new water storage reservoirs may provide flood control benefits downstream if space is dedicated for flood control; and some benefits may occur even without dedicated space. If reservoirs are located offstream in small watersheds, flood control benefits would be relatively small.

New water storage reservoirs may provide flood control benefits downstream if space is dedicated for flood control; some benefits may occur even without dedicated space.

Additional surface storage in the Sacramento or San Joaquin Valleys could benefit flood control in the Delta. Groundwater and off-aqueduct storage would not significantly capture and attenuate substantial stormwater runoff flows and therefore would not affect flood flows.

A dam failure could result in severe flooding. However, this is not considered a significant impact because storage projects would be constructed and operated to reduce the potential for dam failure to less-than-significant levels.

Construction of roads, structures, or other facilities in stream channels could result in increased potential for downstream flooding if the construction activity reduces the carrying capacity of the channel and does not provide an adequate mechanism for controlled release of resulting impounded water. This impact is not considered significant because the construction design would include flow diversion and control structures at dams and stream crossings.

7.8.7.3 BAY REGION

Ecosystem Restoration and Levee System Integrity Programs

No potentially significant impacts are associated with Ecosystem Restoration and Levee System Integrity Programs in the Bay Region, including the Suisun Marsh. However, the Ecosystem Restoration Program includes several actions that would modify flows in the Bay Region, including the establishment of shallow-water habitat, open-water habitat, tidal sloughs, seasonal wetlands, and riparian and shaded riverine habitat. The proposed modifications to flows under the Ecosystem Restoration Program are minor relative to the volume of water in the Bay Region.

No potentially significant impacts are associated with flood control in the Bay Region.

In the Suisun Marsh, about 230 miles, or almost 95%, of the levees are non-project levees. Non-project levees are maintained by local reclamation districts, and maintenance is financed largely by landowners and cost shared by the State.

Maintaining a consistent levee standard in the Suisun Marsh would improve protection of private houses, roads, SWP infrastructure, and critical habitat from floods due to levee failure or over-topping. Levee modifications would protect these structures and resources as well as improve water quality conditions in the western Suisun Marsh.

Levee modifications in the Suisun Marsh would protect structures and resources as well as improve water quality conditions in the western Suisun Marsh.

Watershed Program

No adverse impacts on flood control are anticipated in the Bay Region from Watershed Program actions. Benefits to local flood control resources could occur from Program actions that restore water retention features of watersheds, such as revegetation and runoff control.

Water Quality, Water Use Efficiency, and Water Transfer Programs, and Storage

No actions in Water Quality, Water Use Efficiency, and Water Transfer Programs or the Storage element relate to flood control in the Bay Region.

7.8.7.4 Sacramento River Region

Ecosystem Restoration Program

Restoring the 50- and 100-year floodplains would provide positive flood control benefits. The level of benefit would depend on the existing flood conveyance capacities of the stream channels chosen for improvements. The protection of existing floodplains would provide no benefits over existing conditions. To the extent that future development is prevented in the floodplain, flood benefits would be positive.

Restoring the 50- and 100-year floodplains would provide positive flood control benefits. Removing diversion structures and other obstructions to flow in the Sacramento River tributaries could increase the level of flooding downstream of these diversions.

Removing diversion structures and other obstructions to flow in the Sacramento River tributaries could increase the level of flooding downstream of these diversions. The level of increase would depend on which diversions and obstructions are removed and the total number of obstructions removed. The relative increase in flooding probably would be small for large flood events (for example, a 100-year flood) and relatively larger for small flood events (for example, a 10-year flood). The change in flood levels would depend on how much attenuation of flood flows the existing structures provide. Common flood management measures, such as dredging, levee maintenance, and snag removal would benefit flood control.

Vegetating stream banks could increase flood stages along streams due to increases in the roughness of the stream channel. On wide channels, the increase in roughness of the stream banks probably would result in only a minor impact on flood stage. On small streams, the increase could be significant. Vegetative banks, however, would provide stabilization, thereby benefitting flood control.

Mitigation is available to reduce all potentially significant impacts on flood control that are associated with Ecosystem Restoration Program actions in the Sacramento River Region to less-than-significant levels.

Water Quality and Water Transfer Programs

Effects of the Water Quality and Water Transfer Programs on flood control in the Sacramento River Region are the same as those described for the Delta Region.

Water Use Efficiency Program

Some actions under the Water Use Efficiency Program could affect flood control in the Sacramento River Region. Installation of on-farm efficiency improvements, such as drip and micro-irrigation systems, may require more frequent deliveries from surface water sources or may result in an increased reliance on groundwater. Even at reduced overall volumes, as farmers seek to increase their access to irrigation water, they may need to turn to groundwater pumping if surface water deliveries are unavailable. Increased groundwater pumping may lead to localized ground subsidence. Pumping and subsidence occurring near levees or other flood control facilities could cause settlement of the underlying substrate, resulting in levee slumping or cracking, or more significant damage. Mitigation is available to reduce potentially significant impacts to less-than-significant levels.

Water Use Efficiency Program actions could benefit and adversely affect the flood control system in the Sacramento River Region.

Construction and installation of on-farm water use efficiency improvements, including tailwater recovery ponds or pressurized irrigation systems, could beneficially affect the flood control system by reducing the volume of sediment transported to flood control channels. As sediment load in the receiving channel decreases, the conveyance capacity of the downstream channels is maintained. Further, a lower rate of sediment loading into these channels would require less dredging, thereby reducing flood control system maintenance costs.

Watershed Program

No adverse impacts are anticipated on flood control from Watershed Program actions in the Sacramento River Region. Benefits to local flood control resources could occur from Program actions that restore water retention features of watersheds, such as revegetation and runoff control.

Because no decision has been made concerning whether additional storage would be allocated to flood control, the increased storage is considered unreliable as a flood control measure.

Storage

Increased storage on Sacramento River tributaries could provide localized flood control. Because no decision has been made concerning whether additional storage would be allocated to flood control, the increased storage is considered unreliable as a flood control measure.

Restoring the floodplains along the San Joaquin River south of Vernalis would provide flood control benefits. Presently, the probability of levee failures is high during large storm events in the San Joaquin River Region.

7.8.7.5 San Joaquin River Region

Ecosystem Restoration Program

Reestablishing riparian habitat or preventing the removal of riparian vegetation would result in increasing the roughness of the stream channel and could increase flood stages. On wider channels, the increase in roughness of the stream banks probably would result in only a minor impact on flood stage. On smaller streams, the increase could be significant. Mitigation is available to reduce potentially significant impacts to less-than-significant levels.

Restoring the floodplains along the San Joaquin River south of Vernalis would provide flood control benefits. Presently, the probability of levee failures is high during large storm events in the San Joaquin River Region. By creating a large floodplain, flood stages would be lowered, thereby reducing the pressure on downstream levees. The level of additional protection provided by the floodplain would depend on the size of the floodplain and its location relative to the most vulnerable levees.

Water Quality Program

No adverse effects on flood control are anticipated from Water Quality Program actions. A slight local flood control benefit could occur from reduction in urban and industrial runoff.

Water Use Efficiency and Water Transfer Programs

Impacts on flood control associated with the Water Use Efficiency and Water Transfer Programs in the San Joaquin River Region would be similar to those described for the Sacramento River Region.

Watershed Program

No adverse impacts are anticipated on flood control from Watershed Program actions in the San Joaquin River Region. Benefits to local flood control resources could occur from Program actions that restore water retention features of watershed such as revegetation and runoff control.

Storage

Off-stream storage components could provide some flood control benefit, both by providing additional storage space for flow in the San Joaquin River or Delta and by providing protection to property downstream of the reservoir site. These potential impacts are expected to be minor because no decision has been made concerning whether additional storage would be allocated to flood control. However, the impacts could be important at a local, project-specific level.

Off-stream storage components could provide some flood control benefit, both by providing additional storage space for flow in the San Joaquin River or Delta and by providing protection to property downstream of the reservoir site.

7.8.8 CONSEQUENCES: PROGRAM ELEMENTS THAT DIFFER AMONG ALTERNATIVES

For flood control, the Conveyance element results in environmental consequences that differ among the alternatives, as described below. Under all Program alternatives, proposed north Delta improvements, levee setbacks, and island flooding may affect the economics of flood control by reducing the amount of agricultural land. The south Delta improvements should not affect the economics of flood control.

Under all Program alternatives, proposed north Delta improvements, levee setbacks, and island flooding may affect the economics of flood control by reducing the amount of agricultural land. The south Delta improvements should not affect the economics of flood control.

7.8.8.1 PREFERRED PROGRAM ALTERNATIVE

This section does not include a description of the consequences of a pilot diversion facility because a pilot diversion facility would not result in any impacts on flood control.

Delta Region

Improvements in conveyance through setback levees and dredging under the Preferred Program Alternative likely could result in significant reductions in the 100-year flood stages throughout the north Delta area.

Improvements in conveyance through setback levees and dredging under the Preferred Program Alternative likely would result in significant reductions in the 100-year flood stages throughout the north Delta area.

The Preferred Program Alternative could include several sets of setback levees. These setbacks could significantly increase the floodplain width and result in lower flood stages. Portions of levees could be removed to flood islands. In addition to increasing conveyance capacity, the levee setback removals would lower local water surface elevations and reduce peak flows. This effect likely would propagate a few miles upstream in the North Delta. Dredging to increase water conveyance capacity would result in similar effects to those associated with setback levees. Dredging to increase channel capacity possibly could result in increased channel velocity and erosion.

Levee setbacks and removals could result in two additional impacts. First, lower water surface elevations could result in a steeper hydraulic gradient and higher flow velocities immediately upstream of the levee removal location. The maximum increase in these velocities is expected to be on the order of 1-2 feet per second. Second, lower water surface elevations could change the flow distribution, possibly increasing the volume of water that discharges through the South Fork of the Mokelumne River.

Any island flooding associated with the Preferred Program Alternative could provide only limited flood control benefits, as peak flow rates would be reduced. Island flooding is not expected to significantly lower water surface elevations and, in some cases, would raise water surface elevations downstream of the flooded island.

Island flooding is not expected to significantly lower water surface elevations and, in some cases, would raise water surface elevations downstream of the flooded island.

Gate structures located in channels could reduce the channel's flood flow conveyance, resulting in increased stage upstream of the structures and possibly decreased stage downstream. The amount of increase (or decrease) would depend on the final design of the structures.

Enlargement of the Old River channel could increase the conveyance capacity of this channel, which could result in some localized reductions in flooding.

Changes in operations are not anticipated to adversely affect flood control in the Delta Region. Changes in operations generally would occur during the dry seasons when flood control is not an issue. Any changes in operations occurring during flood control periods, such as additional pumping to make up for water exports loss, are not expected to be significant because of the magnitude of flood flows in comparison to pumping rates.

Changes in operations are not anticipated to adversely affect flood control in any Program region.

Mitigation is available to reduce all potentially significant impacts on flood control in the Delta Region that are associated with the Conveyance element to less-than-significant levels.

Other Program Regions

Conveyance alternatives and changes in operations would not cause significant impacts on flood control in any of the remaining Program regions.

7.8.8.2 ALTERNATIVES 1, 2, AND 3

Most of the flood control benefits result from actions of the Levee System Integrity and Ecosystem Restoration Programs, which are common to all three alternatives and the Preferred Program Alternative. Therefore, differences in flood control impacts between the alternatives and the Preferred Program Alternative would be limited to site-specific setback levees and other Delta conveyance facilities.

Most of the flood control benefits result from actions of the Levee System Integrity and Ecosystem Restoration Programs, which are common to all three alternatives and the Preferred Program Alternative.

Since the Preferred Program Alternative includes the potential widening of Delta channels in addition to Alternative 1 elements, the Preferred Program Alternative would result in a slightly more positive flood control impact than Alternative 1.

Because Alternative 2 includes widening Delta channels to increase channel water conveyance capacity more than the Preferred Program Alternative, Alternative 2 may result in slightly more positive flood control benefits than those of the Preferred Program Alternative or Alternative 1.

Under Alternative 3, an open-channel isolated facility from Hood or Freeport on the Sacramento River to Clifton Court Forebay would not significantly reduce flood flows. A larger isolated facility (15,000 cfs) could lower flood flows for small floods (10-year and

Under Alternative 3, an open-channel isolated facility from Hood or Freeport on the Sacramento River to Clifton Court Forebay would not significantly reduce flood flows.

smaller), but would not significantly affect large floods (100-year and larger). If the 100-year flood flows downstream of Hood or Freeport could be reduced by 15,000 cfs, they would be equivalent to about a 20-year event. This event still would be sufficiently large to cause considerable flooding. If an isolated facility were constructed to prevent flood flows into, over, under, or around it, the facility could act as a dam during similar flooding events. This could cause increased flooding east of the facility and lengthen the time needed for pooled water to drain after the flood wave passes.

7.8.9 PROGRAM ALTERNATIVES COMPARED TO EXISTING CONDITIONS

The programmatic analysis found that the potentially beneficial and adverse impacts from implementing any of the Program alternatives when compared to existing conditions are essentially the same as those identified in Sections 7.8.7 and 7.8.8, which compare Program alternatives to the No Action Alternative. Additionally, the analysis indicates that an overall benefit on flood control would result when the Program alternatives are compared to existing conditions.

The analysis indicates that an overall benefit on flood control would result when the Program alternatives are compared to existing conditions.

The comparison of Program alternatives to existing conditions is the same as the comparison of Program alternatives to the No Action Alternative because existing funding, physical trends, and environmental trends are expected to continue to affect the levee system under the No Action Alternative. In other words, because existing flood control conditions are expected to continue under the No Action Alternative, the effects of the Program alternatives would be the same when compared to either existing conditions or the No Action Alternative.

At the programmatic level, the comparison of the Program alternatives to existing conditions did not identify any potentially significant environmental consequences other than those identified in the comparison of Program alternatives to the No Action Alternative.

The following potentially significant impacts on flood control are associated with the Preferred Program Alternative:

- Impacts on levee stability from levee and berm vegetation management practices for habitat purposes.
- Reduced levee stability from habitat restoration using conservation easements along riparian corridors.
- Increased seepage on adjacent islands, possibly leading to flooding from seepage-induced failure from shallow flooding of Delta islands susceptible to subsidence.

- Increases in wind-fetch and wave erosion on landside levee slopes from island flooding.

- Increased levels of flooding downstream of diversions after removal of diversion structures and other obstructions to flow in the Sacramento River tributaries.

- Increased flood stages along streams due to increases in the roughness of the stream channel from vegetation stream banks.

- Potential localized subsidence, resulting in levee slumping cracking if occurring near levees, caused by potential increases in groundwater pumping.

- Increased stage upstream of and possibly decreased stage downstream from gate structures located in channels that reduce the channel's flood flow conveyance.

- Adverse effects on water quality from the use of dredged materials.

No potentially significant unavoidable impacts on flood control are associated with the Preferred Program Alternative.

7.8.10 ADDITIONAL IMPACT ANALYSIS

Cumulative Impacts. For a summary comparison of cumulative impacts for all resource categories, please refer to Chapter 3. A description of the projects and programs contributing to this cumulative impacts analysis can be found in Attachment A.

The American River Watershed Project, Sacramento River Flood Control System Evaluation, and Sacramento Urban Area Levee Restoration Project are intended to improve flood control resources.

Except for the Bay Region and the Other SWP and CVP Service Areas, Program actions and the projects listed in Attachment A could cause cumulative impacts on flood control.

The American River Watershed Project, Sacramento River Flood Control System Evaluation, and Sacramento Urban Area Levee Restoration Project are intended to improve flood control resources. Urbanization could occur in a manner that would require additional flood control programs. Other projects listed in Attachment A that involve water management activities of environmental restoration projects could adversely affect flood control resources.

Increased flood control resulting from the implementation of Program actions could result in economic or population growth, or the construction of new housing in the Delta Region.

Mitigation strategies have been identified that may reduce the impacts associated with Program actions and other projects described in Attachment A. Nevertheless, cumulative impacts on flood control resources are considered potentially significant.

Growth-Inducing Impacts. Increased flood control resulting from the implementation of Program actions could result in economic or population growth, or the construction of new housing in the Delta Region. Population growth and urban development are generally at the expense of agricultural land and could adversely affect agricultural economics in the Delta. Growth impacts may be limited by existing strict guidelines for Delta land use, and the fact that the PL 84-99 standard is not a FEMA standard for urbanization. Growth inducement from increased flood protection is not likely in the other Program regions.

If improvements in water supply are caused by the Preferred Program Alternative, the Preferred Program Alternative could induce growth, depending on how the additional water supply was used. If the additional water was used to expand agricultural production or urban housing development, the proposed action would foster economic and population growth. Expansion of agricultural production and population could require additional flood control protection and affect flood control resources, but the significance of this impact would depend on where agricultural or population growth occurred and how it was managed.

Short- and Long-Term Relationships. The Preferred Program Alternative generally would maintain and enhance short-term and long-term productivity of flood control resources. Significant overall benefits to the short-term and long-term productivity of flood control result from Program actions. Benefits resulting from levee improvements and increased channel conveyance capacity outweigh the short-term adverse impacts.

Flood control would not be compromised, even in the short term, during construction of levee system improvements.

Any improvement made to a levee is both a short-term and long-term improvement.

Short-term impacts would be related to construction and would cease when construction is complete. Avoidance and mitigation measures would be implemented as a standard course of action to lessen impacts on these resources.

Irreversible and Irretrievable Commitments. The Levee System Integrity Program under the Preferred Program Alternative can be considered to cause significant irreversible changes in flood control resources. Avoidance and mitigation measures can be implemented to lessen adverse effects, but changes will be experienced by future generations. The long-term beneficial irreversible changes include improvements in levees, channel conveyance capacity, and other flood control features. The Levee Integrity Program will cause an irretrievable commitment of resources such as construction materials, labor, energy resources, fill material and land conversion.

7.8.11 MITIGATION STRATEGIES

These mitigation strategies will be considered during project planning and development. Specific mitigation measures will be adopted, consistent with the Program goals and objectives, and the purposes of site-specific projects. Not all mitigation strategies will be applicable to all projects because site-specific projects will vary in purpose, location, and timing.

Although the Program is expected to result in an overall substantial benefit to flood control resources, potentially significant adverse effects have been identified from the Ecosystem Restoration, Levee System Integrity, Water Use Efficiency, and Water Transfer Programs, and the Storage and Conveyance elements. The following mitigation strategies would mitigate these impacts to less-than-significant levels.

The general ecosystem restoration target for levees would be to reduce or eliminate adverse effects on ecological processes, habitats, and dependent species to the extent possible, and in a manner consistent with flood control.

The following mitigation strategies could be used to reduce impacts associated with implementation of the Ecosystem Restoration Program:

- Allowing reasonable clearing of deep-rooted trees and shrubs from levee side slopes to support inspection, maintenance, repair, and emergency response, while preserving some habitat values.

- Permitting clearing of deep-rooted shrubs and trees on levee side slopes. Trees and shrubs should be allowed to grow only on adjacent berms. If roots penetrate levees, fill materials should be added to levee landside slopes in order to construct a partial setback levee and increase stability.

- Widening streams downstream of removed water diversion structures to increase conveyance capacity.

- Incorporating flood control criteria into the design of stream bank revegetation projects. For example, by increasing the width of vegetated sections to maintain conveyance capacity, the net effect of vegetation on flood control would be negligible.

The following mitigation strategies could be used to reduce impacts associated with flooding areas for habitat or water storage under the Ecosystem Restoration Program or Storage element:

- Identifying locations susceptible to seepage-induced failure on Delta islands that may be intentionally flooded for habitat.

- Implementing a seepage monitoring program on nonflooded islands adjacent to potential shallow-flooded islands.

- Developing seepage control performance standards to be used during island flooding and storage periods to determine net seepage caused by shallow flooding.

- Improving levees to withstand expected hydraulic stresses and seepage.

- Designing erosion protection measures to minimize or eliminate wave splash and run-up erosion.

- Using riprap or another suitable means of slope protection to dissipate wave force.

- Constructing large wind/wave breaks in the flooded islands to reduce wind-fetch and erosion potential.

The following mitigation strategies could be used to reduce impacts associated with the Levee System Integrity Program:

- Identifying and investigating issues regarding beneficial reuse of dredge material.

- Continuing the studies concerning reuse of beneficial Bay dredge material in the Delta for potential water quality impacts related to salinity, metals mobilization, and other environmental and health hazards.

- Investigating the cost effectiveness and safety of using sediment traps as a source of borrow.

- Investigating all potential sources of borrow and the cost effectiveness of each source's use for levee rehabilitation and construction.

- Identifying appropriate stockpile locations and management techniques for stabilizing stockpiles against erosion.

- Preparing a borrow plan that includes future costs and options for obtaining adequate quantities of borrow needed for implementation of the Levee System Integrity Program.

The following mitigation strategies could be used to reduce impacts associated with levee settlement due to localized groundwater-pumping-induced subsidence with the Water Use Efficiency and Water Transfer Programs:

- Identifying existing or planned wells that could affect groundwater and substrate conditions underlying nearby levees or flood control facilities.

- Providing incentives to terminate use of wells that can adversely affect levee stability, reducing their pumping volume to safe withdrawal levels as they affect substrate stability, or otherwise replacing them with sources that would not affect levee stability.

The following mitigation strategy could be used to reduce impacts associated with the Conveyance element:

- Designing structures to minimize the loss of channel conveyance at gate structures located in channels.

7.8.12 POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

No potentially significant unavoidable impacts on flood control are expected in any Program region under the Preferred Program Alternative.

No potentially significant unavoidable impacts on flood control are expected in any Program region under the Preferred Program Alternative.